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A Recirculating Stream Aquarium for Ecological Studies

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Abstract

Investigations of the ecological behavior of fishes often require studies in both natural and artificial stream environments. We describe a large, recirculating stream aquarium and its controls, constructed for ecological studies at the Forestry Sciences Laboratory in Corvallis.

Introduction

Environmental studies pose a host of problems for researchers. Natural ecosystems are complex, and investigators often have little control over environmental variables. It is difficult to determine the influence of an individual variable on other variables in a natural ecosystem because all variables operate concurrently. Also, the complexity of environmental research often causes logistical and budgetary problems.

As a result, many ecological studies are conducted in laboratories where researchers have control over environmental variables that influence the study. Under controlled conditions, an investigator can manipulate one variable or a combination of variables while other variables are held constant. Consequently, the effect of a variable is more easily isolated and identified under laboratory conditions.

Both natural and laboratory streams are necessary for studying the impact of human activities on streams. Warren and Davis (1971) present an excellent discussion of the use of laboratory streams for research and the applicability of such research to natural situations.

This paper describes a pair of circular laboratory stream channels constructed at the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory in Corvallis, Oregon. The apparatus was designed to represent small stream habitats that are important spawning and rearing areas for anadromous fish.

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Description of Channels

The channels are oval shaped, measuring 14 by 16 feet (ft) (fig. 1). They are 2.5 ft wide and 2 ft deep, with a total volume of 1,550 gallons.

Each channel consists of eight pieces constructed separately and bolted together (fig. 1). There are four corner pieces 10.3 ft long on the outside and 6.4 ft on the inside and four straight sections, two 2 ft long and two 4 ft long. The bottom of each section is 0.75-inch-thick plywood. The back is 0.25-inch-thick plywood. All wood surfaces are covered with fiberglass and painted with an epoxy paint. Cross supports and uprights were made with 1.5-inch and 1.25-inch angle iron, respectively, and arc-welded together.

The open inner center of the channel is a viewing chamber. Walls of each section are single panes of 0.25-inch-thick plexiglass. A layer of silicone rubber was placed between the glass and the angle iron. The glass was then bolted to the angle iron.

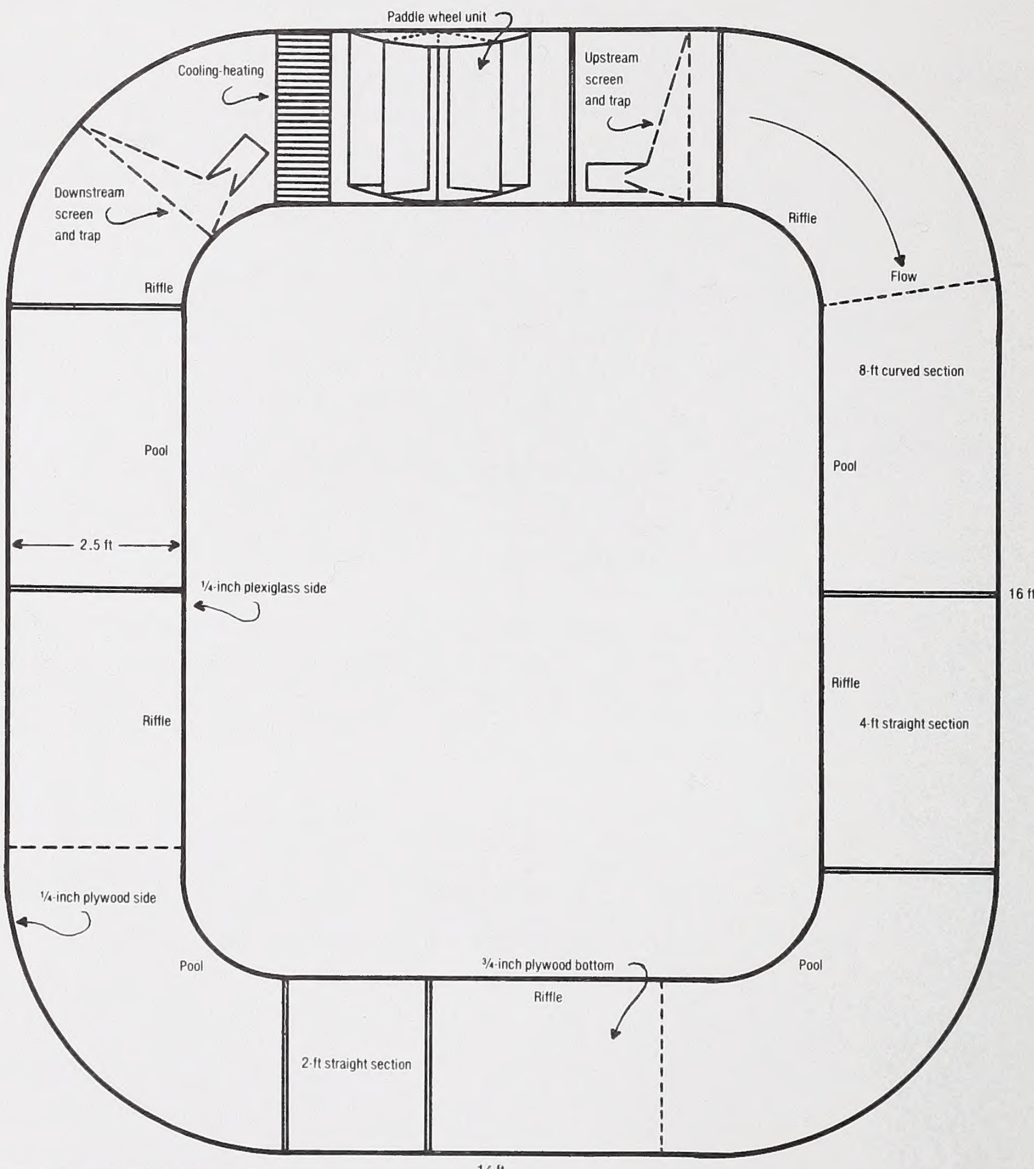

Figure 1.—Laboratory stream channel and major components.

Black polyethylene curtains are suspended around the inside and outside of the channels to eliminate undesired light and other disturbances. The curtains are hung on curtain hooks from a cable attached to the ceiling. This allows the curtains, which extend to the floor, to be moved for easy access to the channels. Slots for observation are cut in the inner curtain at various intervals.

The support structure for the channels is made from Dexion® metal.[1] The channels are set one above the other. The bottom of the lower channel is 16 inches from the floor, vertical distance between channels is 18 inches, and the bottom of the upper channel is 58 inches above the floor. Access to the viewing area is by a stairway over the top of the upper channel. The frame is set on a 1-percent grade (from back to front) to facilitate complete drainage of each channel.

Each channel has independent systems for controlling velocity, lighting, cooling, heating, filtering, feeding, and ultraviolet sterilizing of water. The water depth and the physical structure of habitat, such as riffles, pools, substrate, and cover, within the channel can also be altered.

Two Muskin® model FH40 swimming pool pumps, with a 15-gallon-per-minute capacity, are used to pump water to the filters and feeding boxes. The filter is a stainless steel barrel containing sand. All pipes are 1-inch inside diameter, polyvinyl chloride (PVC).

Water is from the city of Corvallis water supply. Once a channel is filled, only enough water is added continuously to maintain the desired level. Water level is controlled by standpipes of desired height.

The feeding system for each channel consists of a plexiglass box connected to a 5-ft length of pipe. The food box for each channel is installed so that the water level in the box is 48 inches above the water level in the channel. Water pressure from the food box forces brine shrimp (*Artemia* spp.) through small holes in the PVC pipe on the bottom of the channel. The feeding system simulates the natural invertebrate drift food resource of small streams.

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[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

The triangular-shaped food box is made from 0.25-inch plexiglass (fig. 2). The boxes are held in a single frame attached to the ceiling. The bottom of each box is about 24 inches above the top of each channel. The box is divided into two compartments by a piece of 0.25-inch plexiglass. Frozen brine shrimp are placed in the smaller compartment. A small hole, placed slightly above the water level of the front compartment, allows water and thawed brine shrimp to flow from the back to the front compartment. The amount of water flowing to each compartment is controlled by separate valves. An airstone is placed in each compartment to keep the brine shrimp in suspension and increase dispersal time. Water and shrimp from the large compartment flow down to the feeder pipes in the channel. Any excess water drains to the channel via an overflow pipe positioned near the top of the box.

The feeding pipe runs at right angles across the head, diagonally across the length, and at right angles across the tail of riffles. The pipe runs diagonally across pools. It stops 4 ft from the downstream screen to prevent loss of food into the systems control areas of the channels that are not accessible to fish.

Holes one-sixteenth inch in diameter are drilled in the feeding pipe to allow brine shrimp to escape and simulate drifting insects. Pipe in riffles in the upstream half of the channel contains a hole every 6 inches. Holes are every 3 inches in the downstream half and 12 inches in the pools. This arrangement was found to give the best distribution of shrimp throughout the channel.

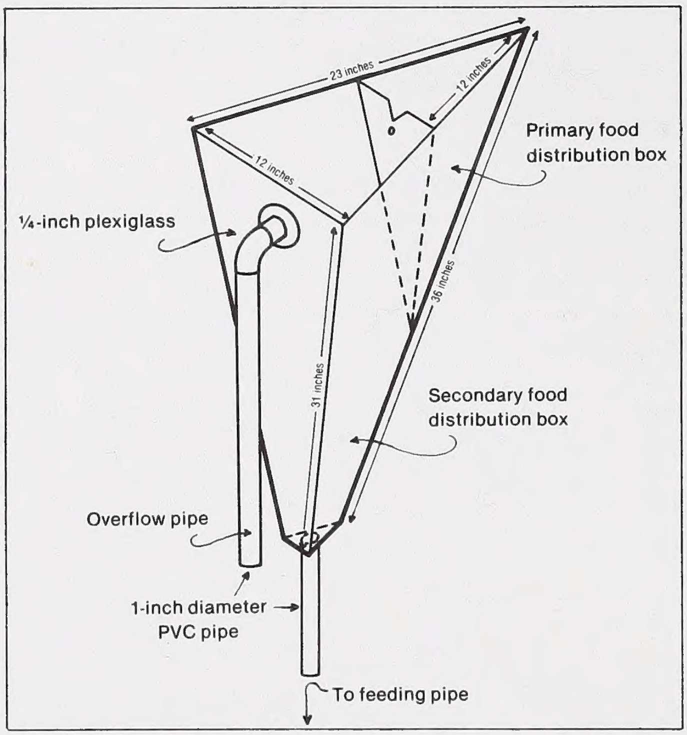

Figure 2.—Dimensions of food boxes for laboratory stream channels.

Water velocity is controlled by a paddle wheel located in each channel. The wheels are made from 0.25-inch-thick plexiglass and are 30 inches in diameter on the ends. There are eight blades, 14 by 26 inches, glued to the end plates; the blades are spaced an equal distance apart. A metal faceplate is mounted on each end of the paddle wheel to support the center shaft. The shaft with bearings is attached to each side of the channel.

Both wheels are belt-driven by a single gear-motor located between the channels. A set of four pulleys on each wheel allows water velocities to be changed. A single idler pulley is used to maintain spring tension on each drive belt. The rotation speed of the paddle wheels can be set to produce a maximum velocity of about 1.5 ft per second, with a volume of flow of about 3 ft^3 per second.

Aquafine® ultraviolet water sterilizers are used to sterilize the water in the channels. Ultraviolet radiation also effectively dechlorinates the water (Seegert and Brooks 1978).

Low temperatures are maintained by a single 3-ton-capacity compressor. Each channel has a chrome- and nickel-plated copper cooling coil controlled by a separate thermostat. Each coil is set directly upstream from the paddle wheel to insure maximum flow over it. High temperatures are maintained by 1500-watt thermostatically controlled immersion heating elements. The controlled temperature capability of the channels ranges from about 33°F to 85°F.

The electrical systems have a total demand of 83 amperes:

Electrical system	Power required (Amperes)
Paddle wheels	4
Filters	10
Ultraviolet sterilizers	2
Lights	12
Refrigeration	24
Heaters (immersion)	26
Miscellaneous valves, timers, aerators	5
Total	83

The electrical power supply is protected with ground-fault interrupters.

The lighting system consists of nine 60-watt bulbs with 12-inch reflectors equally spaced over the area of each channel available to fish. Lights are controlled by a timer device described in detail by Everest and Rodgers (1982) (fig. 3). The device provides a natural diel cycle of sunrise-day-sunset-night.

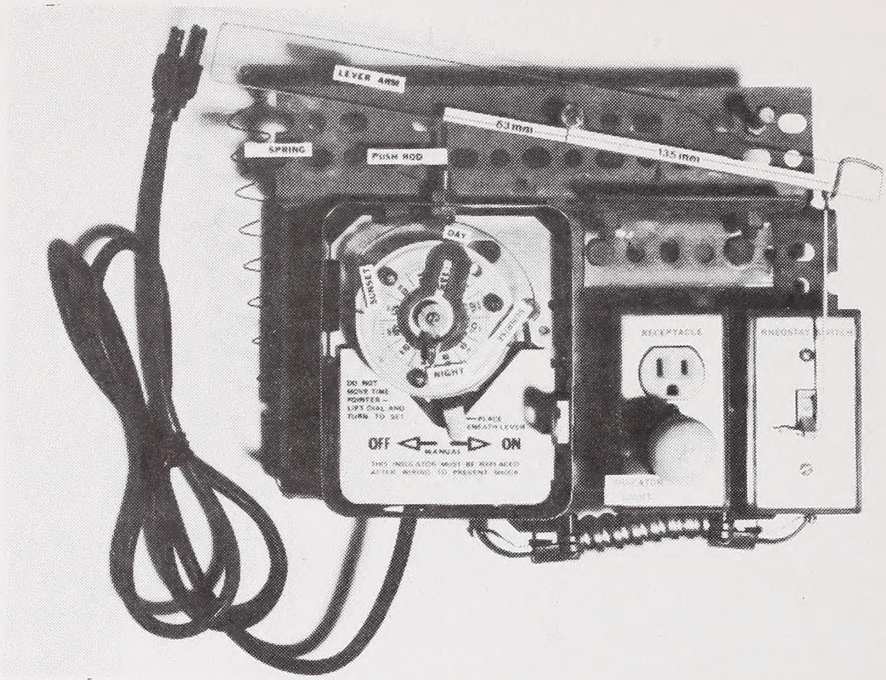

Figure 3.—Light control device simulates natural diel cycle of sunrise-day-sunset-night.

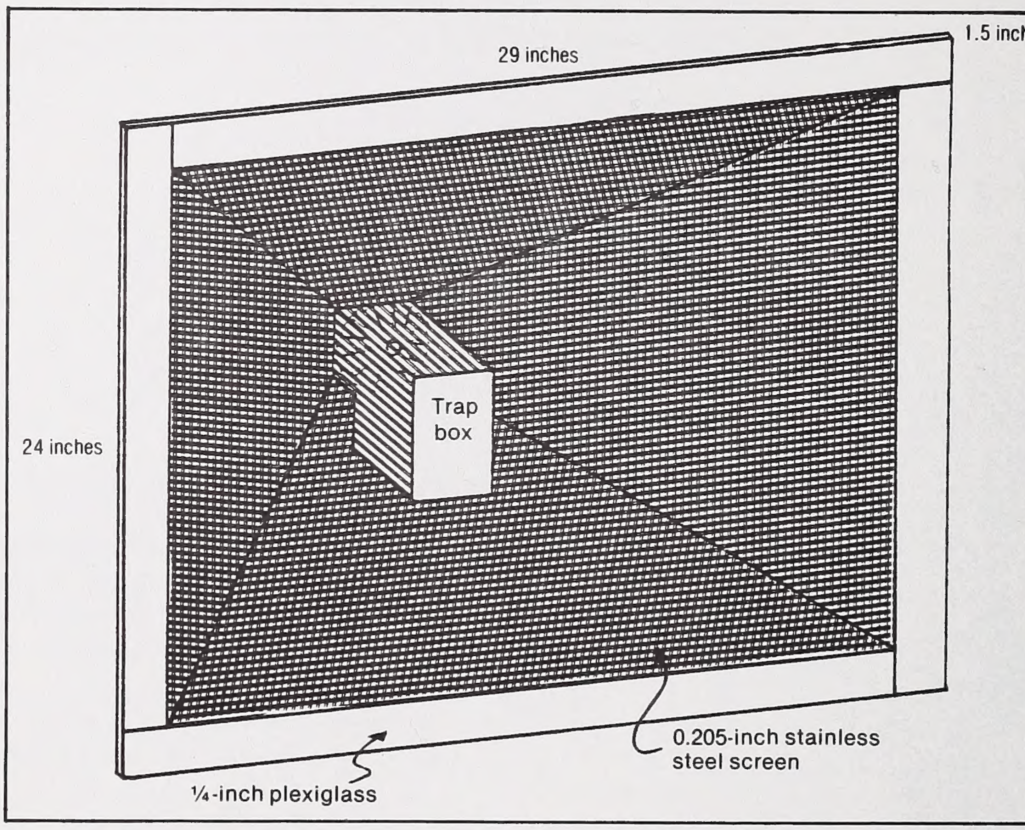

Figure 4.—Screen and trap box used in laboratory streams.

Two screens prevent movement of fish into the area of each channel where the cooling coil and paddle wheel are located (about 8 ft of space). The screens are designed to direct fish attempting to leave the channels into either upstream or downstream trap boxes. The screens are 0.205-inch-mesh stainless steel attached to a 0.25-inch plexiglass frame (fig. 4). They are set in slots formed by plexiglass mounted on the side of the channels. This allows the screens to be removed during cleaning or rearranging the substrate.

A trap box, also made from stainless steel screen, is attached to the back of each screen. The front of the box has a one-eighth-inch plexiglass frame that slides in and out of slots of a plexiglass adapter attached to each screen. A piece of plastic screening forms a narrow fyke at the box opening, through which fish pass to the holding area. The back of the box is plexiglass and is detachable for removing fish.

The bottom configuration of each channel consists of 50 percent pools and 50 percent riffles. Each pool and riffle is about 4 ft long. The pools are 18 inches deep and the riffles 12 to 14 inches. Pools contain sand and some rocks (<2 inches in diameter). Riffles contain rocks 2 to 3 inches in diameter and a few larger rocks. Gravel the size of peas was also placed in the riffles to decrease the amount of intergravel space.

Substrate was placed on platforms made from 0.75-inch plywood to reduce the amount and weight of substrate materials on the riffles. The platforms are 4 inches high by 36 inches long by 29 inches wide and covered with fiberglass resin. A 12-inch-long slope at each end of the platform creates a gradual transition between pools and riffles.

Total cost for the two channels, excluding labor, was about $7,700:

Category	Cost
	(Dollars)
Channel construction	2,646
Refrigeration and heating	2,099
Electrical lighting, etc.	739
Plumbing	625
Filters and pumps	800
Ultraviolet system	800
Total	7,709

Carrying Capacity of Channels

The channels were designed to represent small stream environments and, consequently, primarily are suitable habitat for small fish. Depths, velocities, and cover characteristics of the channels are marginal for salmonids more than 6 inches long, but conditions are excellent for salmonid fry and fingerlings. The carrying capacity of the channels depends on the size of fish introduced. Each channel can accommodate 80 to 100 recently emerged salmonid fry but only 12 to 15 salmonids 5 to 6 inches long. Larger numbers of small, nonterritorial fish with less rigid spatial demands can be accommodated.

Research Opportunities

The channels provide the opportunity for conducting a wide spectrum of research dealing with the ecological behavior of small fishes in a controlled environment. Broad areas of research suitable for the channels include habitat requirements of fishes, the effects of human activities on habitats, fish responses, rehabilitation and enhancement of fish habitat, and studies of interspecific and intraspecific interactions, such as competition or predation.

Metric Equivalents

To convert:	to:	multiply by:
feet	centimeters	30.40
inches	centimeters	2.540
gallons	liters	3.785
(°F)-32	°C	5/9

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